APPENDIX VI:
COMPACTION TESTS

1. INTRODUCTION. In the laboratory compaction test, a soil at a known water content is placed in a specified manner in a mold of given dimensions and subjected to a compactive effort of controlled magnitude after which the resulting unit weight of the soil is determined. The procedure is repeated at various water contents until a relation between water content and unit weight of the soil is established.

The laboratory compaction procedure is intended to simulate the compactive effort anticipated in the field. As a general rule the standard compaction test shall be used to simulate field compaction for routine foundation and embankment design. In special cases, to suit anticipated construction procedures, it may be necessary to use higher or lower compactive efforts on the soil. For a higher compactive effort the modified compaction test, and for a lower compactive effort the 15-blow compaction test shall be used. Details of the standard, modified, and 15-blow compaction tests are given below.

2. STANDARD COMPACTION TEST.

* a. Apparatus. The apparatus consists of the following:

(1) Molds, cylindrical, metal. Molds shall have a detachable base and a collar assembly extending approximately 2-1/2 in. above the top of the mold to retail soil during preparation of compacted specimens of the desired height and volume. Molds having a slight taper to facilitate removal of the specimen after the compaction test are satisfactory provided the taper *

* is no greater than 0.200 in. in diameter per foot of mold height. Capacities and dimensions of the molds shall be as follows:

(a) Mold with an average inside diameter of 4.0 ± 0.016 in. and a capacity of 1/30 ± 0.0004 cu ft. Details of a typical mold are shown in Figure 1.

(b) Mold with an average inside diameter of 6.0 ± 0.016 in. and a capacity of 3/40 ± 0.0009 cu ft. The 6.0-in. mold may be similar in construction to that shown in Figure 1, and shall be used for compacting samples containing material that would be retained on the No. 4 sieve but passing the 3/4-in. sieve.

(c) The exact volume of molds should be determined before use and periodically thereafter, and this measured volume is used in calculations.

(2) Rammer, manually or mechanically operated. The rammer shall consist of a drop weight which can be released to fall freely and strike the soil surface. The height of drop shall be controlled so that the weight falls from a height of 12 ± 1/16 above the surface of the soil. The mass of the free falling part of the rammer shall be 5.5 ± 0.02 lb and the striking face of the rammer shall be flat. Rammers must also meet the following requirements:

(a) Manual rammer. The striking face shall be circular with a diameter of 2.0 ± 0.005 in. The rammer shall be equipped with a guide sleeve having sufficient clearance so that the free fall of the rammer shaft and head will not be restricted. The guidesleeve shall have at least four vent holes at each end (eight holes total) located with centers 3/4 ± 1/16 in. from each *

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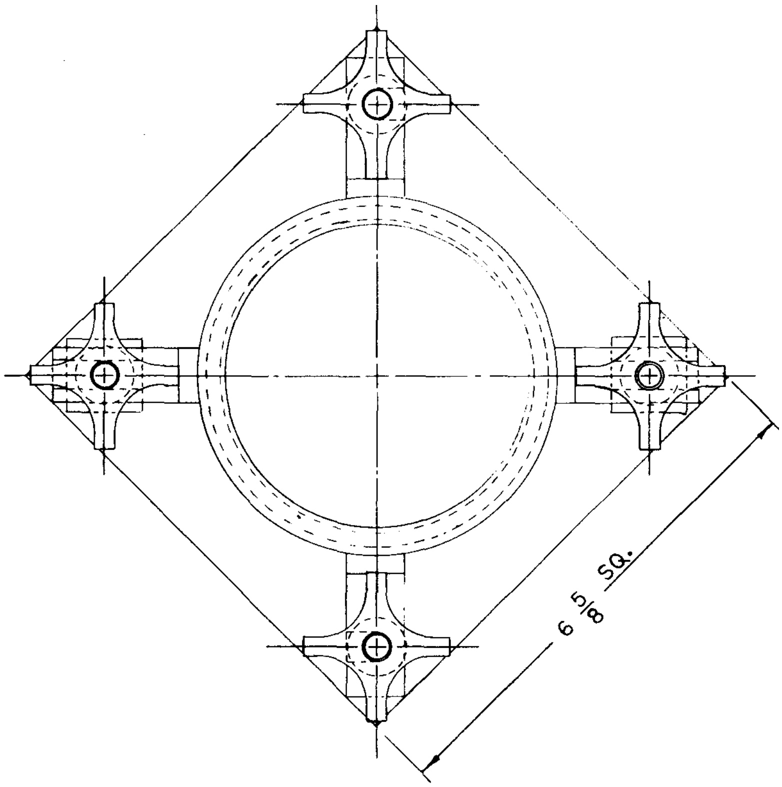

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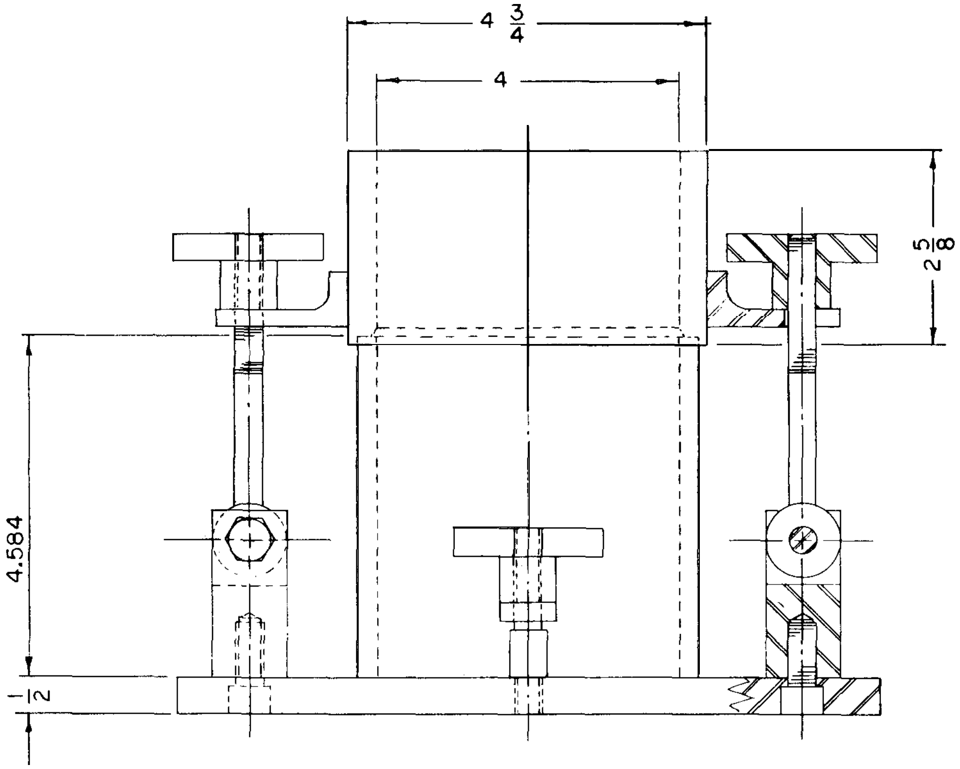

ELEVATION

Figure 1. 4.0-in. diameter compaction mold *

* end and space 90 deg apart. The minimum diameter of the vent holes shall be 3/8 in. Additional vent holes or slots may be incorporated in the guidesleeve if desired. Figure 2 illustrates a typical manual rammer.

(b) Mechanical rammer. A mechanical rammer must operate in such a manner as to provide uniform and complete coverage of the specimen surface. The clearance between the rammer and the inside surface of the mold at its smallest diameter shall be 0.10 ± 0.03 in. When used with the 4-in. mold, the specimen contact face shall be circular with a diameter of 2.000 ± 0.005 in. When used with the 6.0-in. mold, the specimen contact face shall be either circular or sector shaped?; if sector shaped, it shall have a radius of 2.90 ± 0.02 in. The sector face rammer shall operate in such a manner that the vertex of the sector is positioned at the center of the specimen.

(c) Calibration of mechanical rammer compactors. The mechanical rammer compactor must be calibrated periodically against the results obtained with the manual rammer. The compactor must be calibrated for the circular foot and, if used, the sector foot. The mechanical compactor shall be calibrate-d before initial use, near the end of each period during which the mold was filled 500 times before use after anything including repairs that may affect test results whenever test results are questionable, and before use after any 6-month period during which the rammer was not calibrated. Procedures for calibrating mechanical compactors are given in Engineer Manual EM 1110-2-1909, <u>Calibration of Laboratory Soils Testing Equipment.</u> *

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† The mechanical rammer equipped with a sector shaped foot should not be used for compacting specimens for the California Bearing Ratio (CBR) test described in MIL-STD-621A as CBR values may differ substantially from those obtained on specimens compacted with a rammer having a circular foot.

* (3) Balance having a readability of 1 g, an accuracy of 2 g, and having a capacity sufficient for weighing compacted samples.

(4) Oven (see Appendix I, WATER CONTENT - GENERAL).

(5) Sieves, US Standard 3/4-in. and No. 4 (0.187 in.) conforming to ASTM Designation: E 11, Standard Specification for Wire-Cloth Sieves for Testing Purposes. Large sieves are generally more suitable for this purpose.

(6) Straightedge, steel, at least 1/8 × 1-3/8 × 10 in. and having a beveled edge.

(7) Mixing tools, such as mixing pan, spoon, trowel, spatula, etc. A suitable mechanical device may be used for mixing fine-grained soils with water.

(8) Specimen containers. Seamless metal containers with lids are recommended. The containers should be of a metal resistant to corrosion such as aluminum or stainless steel. Containers 2 in. high by 3-1/2 in. in diameter are adequate.

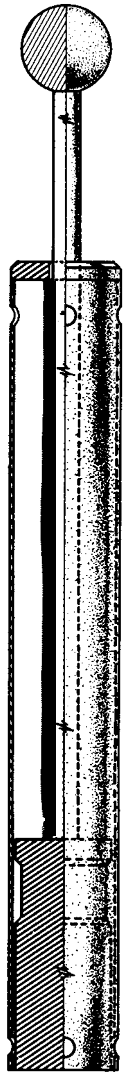

Figure 2. Manual rammer for standard compaction test

* ('9) Sample splitter or riffle for dividing the samples.

(10) Glass jars, metal cans, or plastic buckets with airtight lids in which to store and cure soil prepared for compaction.

(11) Equipment for determining water contents (see Appendix I, WATER CONTENT - GENERAL).

b. Preparation of Sample. The amount of soil required for the standard compaction test varies with the kind and gradation of the soil to be tested. For soils passing the No. 4 sieve that are to be tested in the 4.0-in. mold, 20 lb of soil is normally sufficient for the test. For samples containing gravel that are to be tested in the 6.0-in. mold, approximately 75 lb of processed material is required. Ordinarily, the soil to be tested shall be air-dried, or dried by means of drying apparatus provided the apparatus will not raise the temperature of the sample above 60° C (140° F). The requirement for fully air-drying soils in preparation for compaction is intended to facilitate soil processing and reduce variability in testing procedures. However in some construction control operations, it may not be practical to completely air dry, rewet, and cure the soil in preparation for compaction. In these instances, the soil is air-dried to some water content near the driest point on the compaction curve and water for preparation of individual test specimens added as needed to obtain the desired range of water contents. Partial air drying of some soils during preparation may lead to compaction results different from those which would be obtained if the soil had been completely air-dried during preparation*. If a procedure other than the standard (fully air-dry, rewet, and cure) procedure is used, comparison tests must be performed for each of *

* the soil types encountered at a given project to verify that there is no differences in results. If differences in results do appear, a procedure that reflects the actual field conditions must be adopted for both design and construction control testing.

Aggregations present in the sample shall be thoroughly broken, but care should be taken that the natural size of the individual particles is not reduced. The material shall then be screened through a 3/4-in. and a No. 4 sieve. For some soils, it may be desirable to reduce aggregations before the sample is dried. If all the material passes the No. 4 sieve, the sample shall be mixed thoroughly and a representative sample taken to determine the initial water content (see Appendix I, WATER CONTENT - GENERAL). The sample shall then be stored in an airtight container until ready for processing at different water contents for compaction in the 4.0-in. mold.

If all the sample passes the 3/4-in. sieve and contains 5 percent or less material larger than the No. 4 sieve, the plus No. 4 fraction shall be discarded and the test performed using the 4.0-in. compaction mold. If all the sample passes the 3/4-in. sieve but contains more than 5 percent material retained on the No. 4 sieve, it shall be tested in the 6-in. mold. The sample shall be mixed thoroughly after which its initial water content shall be determined. The sample shall then be stored in an airtight container until ready for processing at different water contents for compaction.

If the sample contains some material retained on the 3/4-in. sieve, but the amount is 5 percent or less, the plus 3/4-in. fraction shall be removed and discarded and the sample tested in the 6-in. mold. The initial water content of the sample shall be determined and the sample stored in an airtight *

* container until ready for processing at different water contents for compaction.

If the sample contains more than 5 percent material retained on the 3/4-in. sieve, the test should be performed using the 12-in. compaction mold, the procedures for which are given in Appendix VIA: COMPACTION TEST FOR EARTH-ROCK MIXTURES.

c. Procedure.

(1) Material finer than No. 4 sieve. The procedure for soils finer than the No. 4 sieve shall consist of the following:

(a) Record all identifying information for the sample such as project name or number, boring number, and other pertinent data on a data sheet (see Plate VI-l for suggested form). Record the compactive effort to be used, size of mold, and initial water content of processed sample.

(b) From the previously prepared sample, weight a quantity of air-dry soil equivalent to 2,500 g oven-dry weight (see paragraph 2d(1)). Thoroughly mix the material with a measured quantity of water sufficient to produce a water content 4 to 6 percentage points below estimated optimum water content. At this water, nonplastic soils tightly squeezed in the palm of the hand will form a cast which will withstand only slight pressure applied by the thumb and fingertips without crumbling; plastic soils will ball noticeably. Store the soil in an airtight container for a sufficient length of time to permit it to absorb the moisture. The time required for complete absorption will vary depending on the type of soil. For nonplastic soils in which

* moisture is readily absorbed, storage is not necessary. For most other soils a minimum curing time of 16 hr is usually adequate.

(c) Repeat step (b) for at least four additional specimens. Increase the water content for each specimen by approximately 2 percentage points over that of the previous specimen.

(d) Weigh the 4.0-in. compaction mold to the nearest gram, and record the weight on the data sheet.

(e) Attach the mold, with collar, to the base plate and place the mold on a uniform, rigid foundation, such as a block or cylinder of concrete weighing not less than 200 lb.

(f) Place an amount of the previously prepared sample in the 4.0-in. mold such that when three such layers have been compacted in the mold, the total compacted'height is between 4-518 in. and 5 in.† Compact each layer by 25 uniformly distributed blows from the rammer, with the drop weight falling freely from a height of 12.0 in. In operating the manual rammer, take care to hold the rammer vertical and avoid rebounding the rammer drop weight from the top of the guidesleeve. Apply the blows at a uniform rate not exceeding 1.4 sec per blow. The compaction procedure is illustrated in Figure 3.

(g) Remove the extension collar from the mold. Remove the exposed compacted soil with a knife and carefully trim *

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† It is important-that the compacted soil just fill the mold with little excess to be struck off. As the amount of material to be struck off varies, the mass of soil to which a constant amount of energy is supplied varies. When the amount of material to be struck off is more than about 1/4 in., the test results become less accurate.

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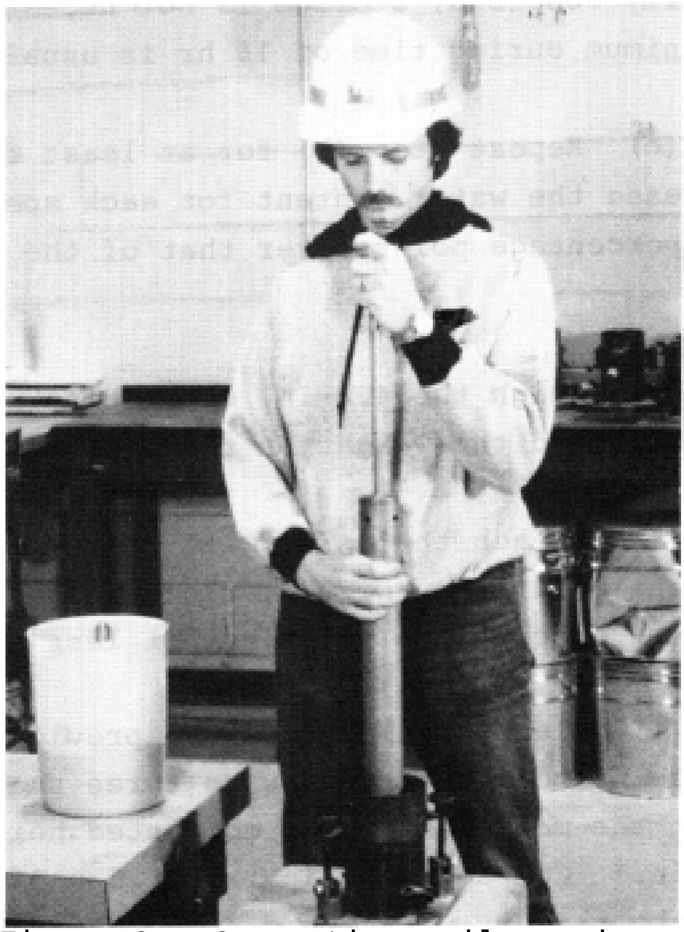

Figure 3. Compacting soil specimen.

the surface even with the top of the mold by means of a straight-edge. Any cavities formed by large particles being pulled out should be carefully patched with material from the trimmings.

(h) Remove the mold with the compacted specimen therein from the base plate, weigh the mold plus wet soil to the nearest gram, and record the weight on the data sheet. When cohesionless soils are being tested there is a possibility of losing the sample if the base plate is removed. For these soils, weigh the entire unit. *

* (i) Remove the compacted specimen from the mold, and slice it vertically through the center. Take a representative specimen of the material from each of the two parts and determine the water content of each (see Appendix I, WATER CONTENT - GENERAL). The water content specimens shall weigh not less than 100 g. Alternatively, the entire compaction specimen may be used for the water content determination. In this case, the wet weight of specimen for use in computing water content should be redetermined after the specimen is extruded from the compaction mold as some loss of material may occur during transfer of the specimen._

(j) Repeat steps (d) through (i) for remaining specimens. Compact a sufficient number of test specimens over a range of water contents to establish definitely the optimum water content and maximum density. Generally, five compacted specimens prepared according to the above-described procedure should completely define a compaction curve. However, sometimes more specimens are necessary. To determine if the optimum water content has been reached, compare the wet weights of the various compacted specimens. The optimum water content and maximum density have been reached if the wettest specimens compacted indicate a decrease in weight in relation to drier specimens.

(2) Materials larger than 3/4 in. sieve. The procedure for determining the density and optimum water content of soils containing material retained on the 3/4 in. sieve is the same as that for the finer than 3/4 in. sieve material, except that the test is performed in the 6.0-in.-diam mold and the number of blows of the compaction rammer is 56 per soil layer instead of 25. This results in equal compactive efforts for the two molds. It is advisable to use the entire compacted specimen for the water content determination. The quantity of soil

* required for each compacted sample will be equivalent to about 5,500 g of oven-dry material.

d. Computations.

(1) Preparation of specimen. The required weight of soil, W'_o, in grams necessary to produce 2,500 g of oven-dry soil is computed as follows:

$$W'_o = W'_s \; 1 + \frac{w_o}{100}$$

where

w_o = initial water content of material (after air-drying)

W'_s = desired weight of oven-dry soil = 2,500 g

The amount of water, W_w, in cc, to be added to the weight of soil, W'_o, to produce specimens at the desired test water contents is computed as follows:

$$W_w = \frac{W'_s \, (w' - w_o)}{100}$$

where

w' = desired test water content

(2) Quantities obtained in compaction test. The following quantities are obtained for each specimen in the compaction test: *

(a) Weight of compaction mold plus wet soil. The weight of the compaction mold is subtracted from this value to obtain the weight of the soil, W.

(b) The inside volume of the compaction mold. This volume is equal to the volume, V, of the wet soil specimen.

(c) Weight of water content specimen plus tare before and after oven-drying. The tare weight is subtracted from these values to obtain the weight of wet and dry soils for computing water content.

(3) Water content and density. The water content, w, of each compacted specimen shall be computed in accordance with Appendix I, WATER CONTENT - GENERAL. The weight of oven-dry soil, W_s, of each compacted specimen shall be computed according to the formula:

$$\text{Dry weight of specimen} = \frac{\text{weight of wet soil}}{1 + \dfrac{\text{water content}}{100}}$$

$$W_s = \frac{W}{1 + \dfrac{w}{100}}$$

The dry weight of the specimen is obtained directly if the entire compacted specimen is used for the water content determination and no loss of material occurs during removal of the specimen from the mold.

The wet unit weight, γ_m, (optional) and the dry unit weight, γ_d, expressed in pounds per cubic foot, shall be computed by the following formulas: *

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$$\text{Wet unit weight} = \frac{\text{weight in g of wet specimen}}{\text{volume in cc of wet specimen}} \times 62.4$$

$$\gamma_m = \frac{W}{V} \times 62.4$$

$$\text{Dry unit weight} = \frac{\text{weight in g of oven-dry specimen}}{\text{volume in cc of wet specimen}} \times 62.4$$

$$\gamma_d = \frac{W_s}{V} \times 62.4$$

These computations may be simplified by use of a mold constant, C , computed as follows:

$$C = \frac{62.4}{V}$$

so that $\gamma_m = CW$ and $\gamma_d = CW_s$.

e. Presentation of Results.

(1) Compaction curve. The results of the standard compaction test shall be presented in the form of a compaction curve on an arithmetic plot as shown in Plate VI-2. The dry densities in pounds per cubic foot are plotted as ordinates and the corresponding water contents in percentage of dry weight as abscissas. The plotted points shall be connected with a smooth curve; for most soils the curve produced is generally parabolic in form. A typical compaction curve is shown in Figure 4. The water content corresponding to the peak of the compaction curve is the optimum water content, and this value shall be recorded to the nearest 0.1 percent. The dry unit weight of the soil in pounds per cubic foot at the optimum water content is the maximum *

* dry density, and this value shall be recorded to the nearest 0.1 lb per cu ft.

(2) Air voids curves. The zero air voids curve (see example in Figure 4) represents the dry density and water content of a soil completely saturated with water. The zero air voids and 90 percent saturation curves shall be shown with the compaction curve in Plate VI-2. Data for plotting these curves for soils with different specific gravities are given in Table VI-l. The specific gravity of the soil used in the compaction test shall be determined in Appendix IV, SPECIFIC GRAVITY.

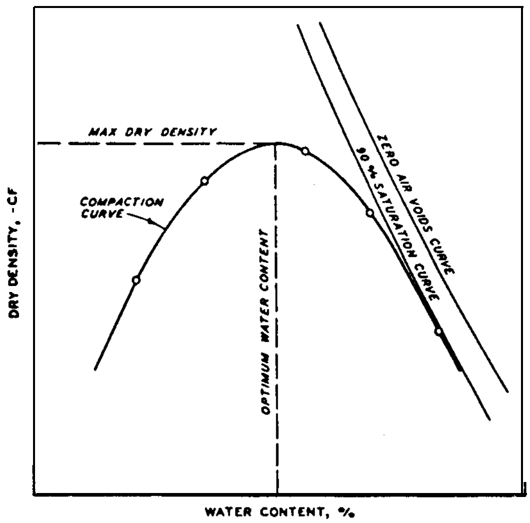

Figure 4. Determination of maximum density and optimum water content

3. MODIFIED COMPACTION TEST. The modified compaction test differs from the standard test in that a greater compactive effort is used which results in higher maximum densities and lower optimum water contents. The apparatus, preparation of sample, and procedure are the same as those used in the standard compaction test, with the following modifications:

a. Apparatus. The rammer shall consist of a 10.00-lb weight with an 18.0-in. free drop. If a mechanical rammer is used in performing these tests, the rammer must be calibrated separately for this test in accordance with procedures given in Engineer Manual EM 1110-2-1909, Calibration of Laboratory Soils Testing Equipment. *

* b. Procedure. The soil shall be compacted in five layers of equal thickness. The number of blows per layer shall be the same as for the standard compaction test: 25 blows per layer in the 4.0-in.-diameter mold, and 56 blows per layer in the 6.0-in.-diameter mold. The computations and presentation of results shall be the same as those used in the standard compaction test.

4. 15-BLOW COMPACTION TEST. The 15-blow compaction test differs from the standard compaction test in that a lesser compactive effort is used resulting in lower maximum densities and higher optimum water contents. The apparatus, preparation of samples, and procedures shall be the same as those used in the standard compaction test (5.50-lb weight with a 12.0-in. free drop) with the following modifications:

a. The 6-in. mold shall not be used.

b. The number of blows per layer shall be 15.

The computations and presentation of results shall be the same as those used in the standard compaction test.

5. POSSIBLE ERRORS. Following are possible errors that would cause inaccurate determinations of compaction curves for any compactive effort:

a. Aggregations of dried soil not completely broken.

b. Water not thoroughly absorbed into dried soil. Consistent results cannot be obtained unless the soil and water are complete mixed and sufficient time allowed for the soil to absorb the water uniformly. *

* c. Soil reused. Since some soils are affected by recompaction, fresh material must be used for each specimen. Recompaction tends to increase the maximum dry unit weight of some clays and, therefore, decrease the apparent optimum water content.

d. Insufficient number of range of water contents to define compaction curve accurately. See paragraph 2c(1)(j).

e. Improper foundation for compaction mold.

f. Incorrect volume of compaction mold used. The exact inside volume of each mold must be determined before being used.

g. Mechanical compactor not properly calibrated.

h. Human factors in the operation of hand rammer. Variations in results can be caused by not bringing the drop weight to a complete stop before releasing it to fall and compact the soil. If raising and releasing the rammer's drop weight is done too quickly, the drop weight will not be brought to rest before release. If the rammer is not held vertical during operation, the compactive effort will be reduced. The tendency to press the sleeve of the manual rammer into the soil specimen, the way the blows are distributed over the surface of the specimen, and other individual operator characteristics all tend to affect compaction results. By proper instruction and supervision, uniform technique can be maintained within a laboratory; however, it is preferable that all specimens of a given test be compacted by the same person with the same rammer in one sitting.

i. Excessive variation in total depth of compacted specimen. The extension of the specimen into the collar of the mold *

* should not exceed about 1/4 in., and care should be taken that each layer is nearly equal in weight.

j. Water content determination not representative of specimen. This error can be avoided by using the entire specimen for the water content determination.

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Table VI-1

Data for Zero Air Voids Curve

Specific Gravity of Soil	Water Content, w, in Per Cent of Dry Weight for Dry Unit Weight, γ_d, in pounds per cubic foot of																			
	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
2.40	83.2	71.8	62.4	54.4	47.5	41.6	36.4	31.8	27.7	24.1	20.8	17.8	15.1	12.6	10.4	8.3	6.4	4.6	2.9	1.4
2.45	84.0	72.7	63.2	55.2	48.4	42.4	37.2	32.6	28.6	24.9	21.6	18.6	15.9	13.5	11.2	9.1	7.2	5.4	3.8	2.2
2.50	84.9	73.5	64.1	56.1	49.2	43.2	38.0	33.5	29.4	25.7	22.4	19.5	16.8	14.3	12.0	9.9	8.0	6.2	4.6	3.1
2.51	85.0	73.7	64.2	56.2	49.4	43.4	38.2	33.6	29.5	25.9	22.6	19.6	16.9	14.5	12.2	10.1	8.2	6.4	4.8	3.2
2.52	85.2	73.8	64.4	56.4	49.5	43.6	38.4	33.8	29.7	26.0	22.8	19.8	17.1	14.6	12.4	10.3	8.3	6.6	4.9	3.4
2.53	85.3	74.0	64.5	56.5	49.7	43.7	38.5	33.9	29.8	26.2	22.9	19.9	17.2	14.8	12.5	10.4	8.5	6.7	5.1	3.5
2.54	85.5	74.1	64.7	56.7	49.8	43.9	38.7	34.1	30.0	26.4	23.1	20.1	17.4	14.9	12.7	10.6	8.7	6.9	5.2	3.7
2.55	85.6	74.3	64.8	56.8	50.0	44.0	38.8	34.2	30.2	26.5	23.2	20.2	17.5	15.1	12.8	10.7	8.8	7.0	5.4	3.8
2.56	85.8	74.5	65.0	57.0	50.1	44.2	39.0	34.4	30.3	26.7	23.4	20.4	17.7	15.2	13.0	10.9	9.0	7.2	5.5	4.0
2.57	86.0	74.6	65.1	57.1	50.3	44.3	39.1	34.5	30.5	26.8	23.5	20.6	17.8	15.4	13.1	11.0	9.1	7.3	5.7	4.2
2.58	86.1	74.8	65.3	57.3	50.4	44.5	39.3	34.7	30.6	27.0	23.7	20.7	18.0	15.5	13.3	11.2	9.3	7.5	5.8	4.3
2.59	86.3	74.9	65.4	57.4	50.6	44.6	39.4	34.8	30.8	27.1	23.8	20.9	18.1	15.7	13.4	11.3	9.4	7.6	6.0	4.5
2.60	86.4	75.1	65.6	57.6	50.7	44.8	39.6	35.0	30.9	27.3	24.0	21.0	18.3	15.8	13.6	11.5	9.6	7.8	6.1	4.6
2.61	86.6	75.2	65.7	57.7	50.9	44.9	39.7	35.1	31.1	27.4	24.1	21.2	18.4	16.0	13.7	11.6	9.7	7.9	6.3	4.8
2.62	86.7	75.3	65.9	57.9	51.0	45.1	39.9	35.3	31.2	27.6	24.3	21.3	18.6	16.1	13.9	11.8	9.9	8.1	6.4	4.9
2.63	86.8	75.5	66.0	58.0	51.2	45.2	40.0	35.4	31.4	27.7	24.4	21.4	18.7	16.3	14.0	11.9	10.0	8.2	6.6	5.0
2.64	87.0	75.6	66.2	58.2	51.3	45.4	40.2	35.6	31.5	27.8	24.6	21.6	18.9	16.4	14.2	12.1	10.1	8.4	6.7	5.2
2.65	87.1	75.8	66.3	58.3	51.5	45.5	40.3	35.7	31.6	28.0	24.7	21.7	19.0	16.6	14.3	12.2	10.3	8.5	6.9	5.3
2.66	87.3	75.9	66.5	58.5	51.6	45.7	40.5	35.9	31.8	28.1	24.8	21.9	19.2	16.7	14.4	12.4	10.4	8.7	7.0	5.5
2.67	87.4	76.1	66.6	58.6	51.7	45.8	40.6	36.0	31.9	28.3	25.0	22.0	19.3	16.8	14.6	12.5	10.6	8.8	7.1	5.6
2.68	87.6	76.2	66.7	58.7	51.9	45.9	40.7	36.1	32.1	28.4	25.1	22.2	19.4	17.0	14.7	12.6	10.7	8.9	7.3	5.8
2.69	87.7	76.3	66.9	58.9	52.0	46.1	40.9	36.3	32.2	28.6	25.3	22.3	19.6	17.1	14.9	12.8	10.9	9.1	7.4	5.9
2.70	87.8	76.5	67.0	59.0	52.2	46.2	41.0	36.4	32.3	28.7	25.4	22.4	19.7	17.3	15.0	12.9	11.0	9.2	7.6	6.0
2.71	88.0	76.6	67.2	59.2	52.3	46.3	41.1	36.6	32.5	28.8	25.5	22.6	19.9	17.4	15.1	13.0	11.1	9.3	7.7	6.2
2.72	88.1	76.8	67.3	59.3	52.4	46.5	41.3	36.7	32.6	29.0	25.7	22.7	20.0	17.5	15.3	13.2	11.3	9.5	7.8	6.3
2.73	88.2	76.9	67.4	59.4	52.6	46.6	41.4	36.8	32.7	29.1	25.8	22.8	20.1	17.7	15.4	13.3	11.4	9.6	8.0	6.4
2.74	88.4	77.0	67.6	59.6	52.7	46.7	41.5	37.0	32.9	29.2	25.9	23.0	20.3	17.8	15.5	13.4	11.5	9.7	8.1	6.6
2.75	88.5	77.2	67.7	59.7	52.8	46.9	41.7	37.1	33.0	29.4	26.1	23.1	20.4	17.9	15.7	13.6	11.7	9.9	8.2	6.7
2.76	88.6	77.3	67.8	59.8	53.0	47.0	41.8	37.2	33.1	29.5	26.2	23.2	20.5	18.1	15.8	13.7	11.8	10.0	8.4	6.8
2.77	88.8	77.4	68.0	60.0	53.1	47.1	41.9	37.4	33.3	29.6	26.3	23.4	20.7	18.2	15.9	13.8	11.9	10.1	8.5	7.0
2.78	88.9	77.5	68.1	60.1	53.2	47.3	42.1	37.5	33.4	29.8	26.5	23.5	20.8	18.3	16.1	14.0	12.1	10.3	8.6	7.1
2.79	89.0	77.7	68.2	60.2	53.4	47.4	42.2	37.6	33.5	29.9	26.6	23.6	20.9	18.5	16.2	14.1	12.2	10.4	8.8	7.2
2.80	89.2	77.8	68.3	60.3	53.5	47.5	42.3	37.7	33.7	30.0	26.7	23.8	21.0	18.6	16.3	14.2	12.3	10.5	8.9	7.4
2.81	89.3	77.9	68.5	60.5	53.6	47.7	42.5	37.9	33.8	30.1	26.8	23.9	21.2	18.7	16.4	14.4	12.4	10.7	9.0	7.5
2.82	89.4	78.1	68.6	60.6	53.7	47.8	42.6	38.0	33.9	30.3	27.0	24.0	21.3	18.8	16.6	14.5	12.6	10.8	9.1	7.6
2.83	89.5	78.2	68.7	60.7	53.9	47.9	42.7	38.1	34.0	30.4	27.1	24.1	21.4	19.0	16.7	14.6	12.7	10.9	9.3	7.7
2.84	89.7	78.3	68.8	60.8	54.0	48.0	42.8	38.2	34.2	30.5	27.2	24.3	21.5	19.1	16.8	14.7	12.8	11.0	9.4	7.9
2.85	89.8	78.4	69.0	61.0	54.1	48.2	43.0	38.4	34.3	30.6	27.3	24.4	21.7	19.2	16.9	14.9	12.9	11.2	9.5	8.0
2.86	89.9	78.5	69.1	61.1	54.2	48.3	43.1	38.5	34.4	30.8	27.5	24.5	21.8	19.3	17.1	15.0	13.1	11.3	9.6	8.1
2.87	90.0	78.6	69.2	61.2	54.4	48.4	43.2	38.6	34.5	30.9	27.6	24.6	21.9	19.5	17.2	15.1	13.2	11.4	9.8	8.2
2.88	90.1	78.8	69.3	61.3	54.5	48.5	43.3	38.7	34.7	31.0	27.7	24.7	22.0	19.6	17.3	15.2	13.3	11.5	9.9	8.3
2.89	90.3	78.9	69.5	61.5	54.6	48.6	43.4	38.9	34.8	31.1	27.8	24.9	22.2	19.7	17.4	15.3	13.4	11.6	10.0	8.5
2.90	90.4	79.0	69.6	61.6	54.7	48.8	43.6	39.0	34.9	31.2	28.0	25.0	22.3	19.8	17.6	15.5	13.5	11.8	10.1	8.6
2.95	91.0	79.6	70.2	62.2	55.3	49.3	44.1	39.6	35.5	31.8	28.5	25.6	22.9	20.4	18.1	16.0	14.1	12.3	10.7	9.2
3.00	91.5	80.2	70.7	62.7	55.9	49.9	44.7	40.1	36.0	32.4	29.1	26.1	23.4	21.0	18.7	16.6	14.7	12.9	11.3	9.7
3.05	92.1	80.7	71.3	63.3	56.4	50.5	45.3	40.7	36.6	32.9	29.6	26.7	24.0	21.5	19.2	17.2	15.2	13.5	11.8	10.3
3.15	93.1	81.8	72.3	64.3	57.4	51.5	46.3	41.7	37.6	34.0	30.7	27.7	25.0	22.5	20.3	18.2	16.3	14.5	12.8	11.3

Note: Zero air voids curve equivalent to a degree of saturation, S , equal to 100 percent.

$$w = S\left(\frac{\gamma_w}{\gamma_d} - \frac{1}{G_s}\right)$$

where

- w = water content, percent
- S = degree of saturation, percent
- γ_w = unit weight of water, lb per cu ft = 62.43
- γ_d = dry unit weight of soil, lb per cu ft
- G_s = specific gravity of soil solids

This equation may also be used to determine curves representing degrees of saturation other than 100 percent.

*

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COMPACTION TEST

Date ______________________

Project ____

Boring No. ____________________________ Sample No. ____________________

Mold No.	inch diam mold	Volume of mold, V, in cc =
Mold constant, C = 62.4 ÷ V =		Initial water content, w_o =
blows per each of	layers, with lb rammer	inch drop

Specimen No.							
Preparation of specimen							
$100 + w_o$							
Weight in grams: Oven-dry soil	W_s'						
Weight in grams: Wet soil $= \frac{W_s'(100 + w_o)}{100}$	W_o'						
Weight in grams: Tare							
Weight in grams: Tare plus wet soil							
Test water content	w'	%	%	%	%	%	%
Water added in cc $= \frac{W_s'(w' - w_o)}{100}$							
Compacted specimen							
Weight in grams: Mold plus wet soil							
Weight in grams: Mold tare							
Weight in grams: Wet soil	W						
Weight in grams: Dry soil $= \frac{100\ W}{100 + w}$	W_s						
Water content $= \frac{W - W_s}{W_s} \times 100$	w	%	%	%	%	%	%
lb per cu ft: Wet unit wt = CW	γ_m						
lb per cu ft: Dry unit wt = CW_s	γ_d						
Water content determinations							
Specimen No.							
Tare No.							
Weight in grams: Tare plus wet soil							
Weight in grams: Tare plus dry soil							
Weight in grams: Water	W_w						
Weight in grams: Tare							
Weight in grams: Dry soil	W_s						
Water content $= \frac{W_w}{W_s} \times 100$	w	%	%	%	%	%	%

Remarks ____

____

Technician ____________________ Computed by ________________ Checked by ________________

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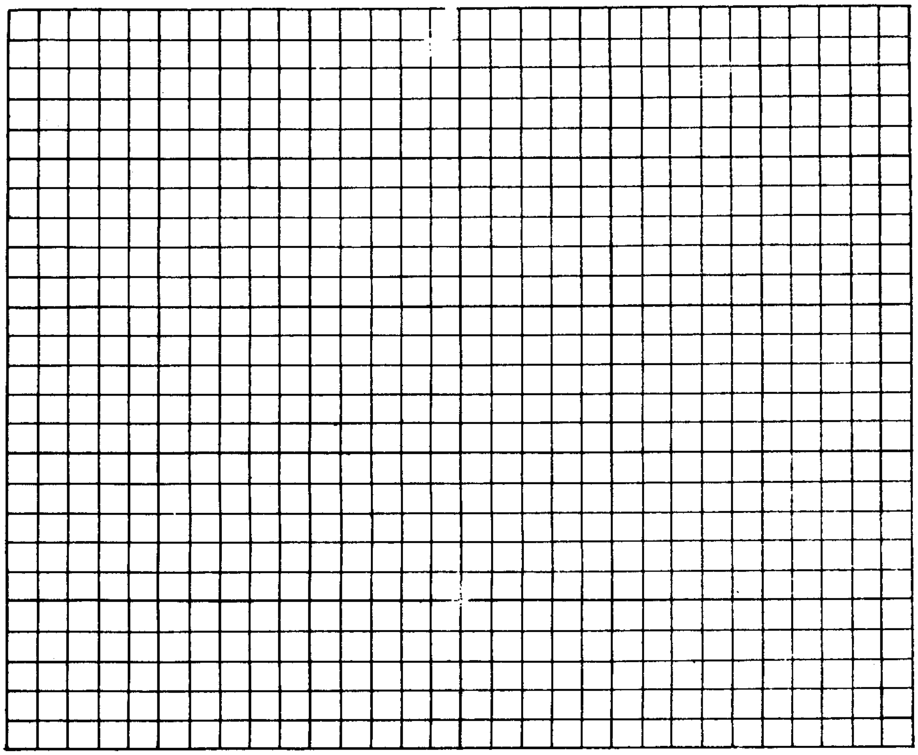

_______________compaction test

__________ blows per each of__________ layers, with __________ lb rammer and

__________ inch drop. __________ inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.

Sample No.				
Natural water content, percent				
Optimum water content, percent				
Max dry density, lb/cu ft				

Remarks	Project	
	Area	
	Boring No.	Date
	COMPACTION TEST REPORT	

ENG FORM 1 JUN 65 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

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